Inter-Office Memorandum

GPU Service

Date April 12, 1979
TSG 016

Subject Cooldown of TMI-2

To R. C. Arnold

Location Three Mile Island

As part of the overall plan for placing TMI-2 in a long term stable mode, the reactor will be placed into natural circulation. Preliminary to the natural circulation transition, a decrease in primary plant temperature will be required. It is proposed that the initial step in this direction be taken immediately by steaming down on the A generator by opening further the turbine bypass valve. It is anticipated the primary system would be cooled from its present 285° to approximately 220° - 230°. The attachment to this memo briefly reviews several of the considerations relating to the steamdown. The end point configuration of the reactor does not appear to result in any additional risk, current emergency procedures should be adequate and the system will be in a stable mode.

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B&W Concurrence

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98 042

PROPOSAL

Cooldown (A-B) of TMI-2 While Steaming on A Steam Generator

1. Method:

   a) Steam from S/G A to the main condenser controlling flow with the turbine bypass valves.

   b) A slow cooldown rate less than 10°F/hour will be specified.

   c) Maintain pressure at about 1000 psi. Controlled depressurization is permitted to check gas concentration.

   d) Continue degassing at maximum rate.

   e) Monitor core thermocouples, neutron monitors and noise levels to determine any anomolous output.

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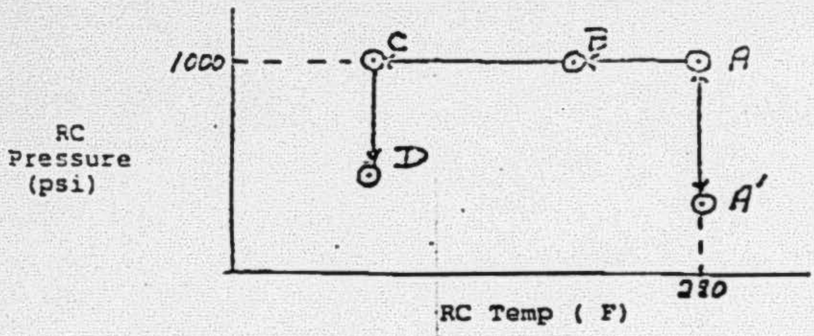
TMI-2 Recovery
BASE CASE SUMMARY (Revision 2)



(1) Degas at A. Lower pressure (A→A') while degassing, then return to A.

(2) Continue design/installation of static & active systems for primary makeup/level control and secondary cooling system for S/G "B".

(3) Reduce temperature (A→B) by steaming on "A" S/G. Verify operability of secondary cooling system for "B" S/G.

(4) At B, establish solid cooling to "B" S/G, and when stable, isolate "A" S/G.

(5) Reduce temperature (B→C) with S/G "B". As soon as possible, start solid operation with "A" S/G, with modification pkg to be determined.

(6) At C, trip RC Pump "A" and establish natural circulation in "A" and "B" loops.

(7) Reduce primary pressure to value to be determined (C→D).

(8) Take primary system solid - activate new MU/pressure control system.

END POINT
Primary: Natural circulation, solid water, long term P/V control
Secondary: Solid water, long term heat dump system

APPROVED FOR ISSUE:

R. C. Arnold

98 044

7. Technical Issues

a. Effect on Shutdown Margin & Boron

The reduction in RC temperature from 280° to 230°F will slightly decrease the core shutdown margin. However, the expected change in reactivity is small in comparison with the amount of excess boron concentration in the coolant. For example, for a clean core with all rods at zero power, the required boron concentrations are as follows:

Temperature	Keff	Boron Conc. ppm
70°F	0.99	1057
532°F	0.99	741
Δ = 462°F		Δ = 316 ppm

Thus, an increase of only about 50/462 x 316 ≅ 34 ppm boron should compensate for the temperature reduction. In actuality, the boron concentration is currently in the 2600 - 3400 ppm range, such that adequate shutdown margin will be maintained (calculations from FSAR).

B&W analysis on TMI-2 criticality evaluates a broad spectrum of fuel configurations ranging from the intact core to homogenous solutions of uranium and water (references B&W submittal to Met-Ed entitled, "Safety Evaluation Information for Transition to Natural Circulation Cooling", dated 4/11/79, Section 3.9).

The conservative calculations and the assumptions on the core configuration have led B&W to recommend a boron concentration of 3000 ppm. They have confirmed that lowering temperature from 280°F to about 230°F does not affect their recommendations on criticality or boron concentration.

Further, nuclear instrumentation will be monitored during cooldown to confirm that adequate shutdown margin is maintained.

The effect of reducing RC temperature from 280°F to about 230°F will be to decrease the boron solubility in the coolant. However, in the temperature range of interest (280° - 230°F) the boron solubility is more than a factor of ten greater than expected boron concentrations. (e.g., boron solubility at 200°F is about 44000 ppm) As a result, the temperature reduction should have no significant effect on boron precipitation.

Calculations by GPUSC indicate that in the temperature and boron concentration range of interest, decreasing temperature 280° - 230°F decreases reactivity. The reason for this is that in this temperature range the change in cross section is greater than the change in moderation due to density change.

b. System Gas Considerations

1) Since pressure has been as low as about 300 psia and conservatively assuming that the RC was saturated with non-condensibles at 300 psia, 280°F, the concentration of H_2 would be about 52 ppm. At 1000 psia, 280°F, the concentration would be 175 ppm if saturated, and at 1000 psia, 230°F, the saturated concentration would be 115 ppm. Clearly a decrease in temperature from 280°F to 230°F would not cause non-condensibles to come out of solution since the existing H_2 concentration is below the saturation concentration at 1000 psia and 230°F.*

2) Reducing RC temperature from 280°F to 230°F would tend toward reducing solubility of H_2 in the makeup tank which would improve degassing effectiveness.

3) Lower RC temperature would tend to reduce flashing and amount of gases coming out of solution in the letdown line. Assuming the major pressure drop is across the letdown coolers, two phase flow could exist in downstream piping and filters. This will reduce total mass flow rate due to the high volumetric flow associated with the two phase condition. A reduction in temperature would therefore tend to increase mass flow rate and improve the degassing effectiveness.

4) Solubility of N_2, O_2, and H_2 is shown in the attached figure. Note that in each case a reduction in temperature from 280°F to 230°F would result in a reduction in gas solubility in the makeup tank.

* Multiply ppm by 11.2 to obtain cc/kg.

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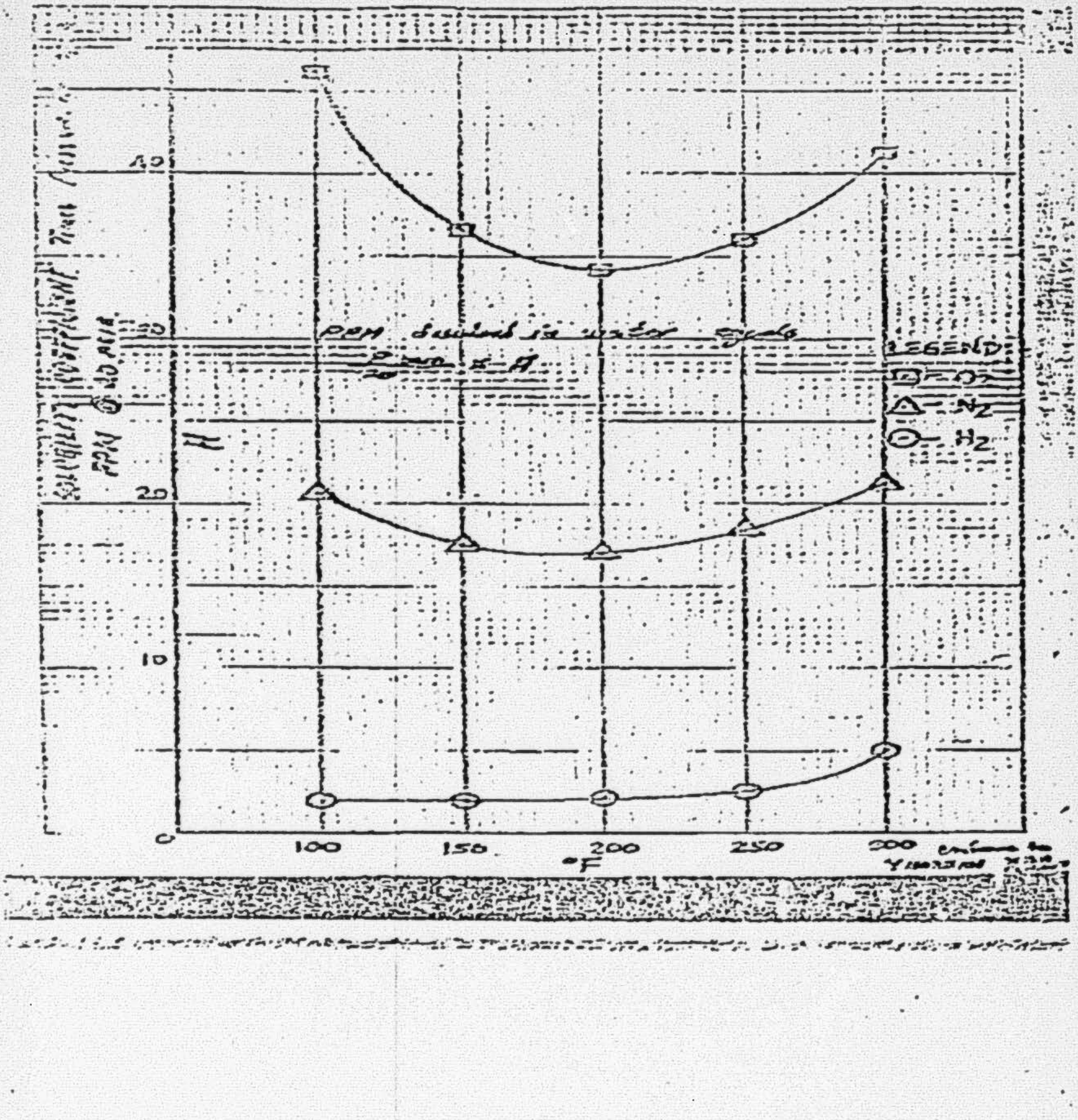

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c. Vessel Pressure - Temperature Limits

Reference: D. A. Roy memo to E. Rogers dated 4/10/79 (transmittal W154) - 8:35 p.m.

B&W has evaluated the reactor vessel using conservative flow size assumptions (1/4 of vessel shell or nozzle thickness) and, in accordance with the ASME Code, Section III, Appendix G and has provided Met Ed with allowable RCS pressure as a function of system temperature. (See attached curve from referenced memo.)

The curve shows that for temperatures above 160° F, the system pressure can rise to the setpoint of the pressurizer safety reliefs (2500 psi) without concern. The range of temperatures during this evolution (280° F down to about 200° F or whatever lower temperature can be achieved by steaming) are covered by this limit (2500 psi) and, therefore, no special precautions need be considered to limit pressure.

B&W has confirmed that cooldown rates equal or less than 10°F/hr have no adverse effect on vessel or system integrity.

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d. Impact on Contingency Plans

A review of the existing contingency plans prepared or under preparation for the current plant conditions (1000 psig, 285°F, steaming on "A" steam generator, 1 RCP running in the "A" loop) was made, and it was concluded that no changes need be made to accommodate the change from 280°F to about 220°F (or whatever minimum temperature can be achieved while steaming). Contingency plans will be revised to reflect future changes in state not covered in this proposal (such as changing the cooling mode from steaming to solid water, changing pressure from forced to natural circulation). Contingency plans are constantly being updated to reflect improving knowledge of the expected plant behavior in each mode of operation.

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c. Core Flood Tanks

The core flood tanks should not be affected by this cooldown. They should remain in their existing condition, valved out with N_2 overpressure.

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C. Thermal Considerations

General thermal considerations relating to the core cooldown under forced circulation include the following:

1. Increased subcooling would improve core heat transfer and reduce the degree of nucleate boiling that may be occurring in the core. It is considered preferrable to keep fuel rods of uncertain mechanical condition immersed in subcooled water than to permit local boiling which could lead to the possibility of pockets of steam in obstructed regions.

2. Lower RCS temperature reduces the risk of flashing in the event that an unexpected pressure reduction occurs. Flashing could have adverse consequences in a core of uncertain mechanical stability.

3. Reduced temperature should provide some minor reduction in the general stress on system components subject to RCS and containment environment.

4. In the case of an RCP trip, a lower temperature provides a greater system heat sink capability (primary and secondary water and system materials) and, therefore, provides more time for action. The additional margin to saturation (as long as pressure is held constant) also provides additional time for emergency response. In terms of natural circulation, a lower temperature starting point provides a greater margin to hot leg boiling, thus maximizing the potential for preservation of natural circulation.

5. Lower temperatures in the RCS present no siginificant disadvantage in terms of the emergency initiation of natural circulation.

g. Reversibility

If there are any unexpected results from this cooldown, the evolution is completely reversible by reducing or eliminating the steam flow to the condenser letting the RCS heat up. The slow rate of cooldown permits easy identification of problems and time to react should problems occur.

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n. Pressurizer Level Calibration

Current activities to develop correlations so that pressurizer level can be inferred from other measurable plant parameters should not be affected by this minor change in plant temperature. Pressurizer level must be maintained during the cooldown by adding makeup to the system to compensate for thermal contraction. If pressurizer level becomes unavailable, the cooldown should be halted until the actions necessary to infer pressurizer level can be done or pressurizer level indication can be restored. When the cooldown to about 220°F is completed, the test used to establish the correlation between rate of change of pressure as a function of pressurizer level will be repeated to ensure the data base for inferring pressurizer level is still applicable.

i. Primary Coolant Leakage

Primary coolant leakage is not expected to be affected noticeably by the proposed cooldown.

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3. Precautions

a) A procedure to accomplish this evolution will be provided.

b) A slow cooldown rate of nominally 2 - 4°F will be specified based on the judgement that moving slowly is in no way a disadvantage and has several advantages including ready recognition of changes in conditions and easy reversibility.

c) Source range instrumentation will be monitored for criticality, noise monitors will be monitored for abnormal indications, and core thermocouples will be monitored for abnormal temperature fluctuations. Specific guidance on action levels will be provided in the procedure for cooldown.

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